Hybrid Stereo Camera

An IBR Approach for Synthesis of Very High Resolution Stereo Image Sequences

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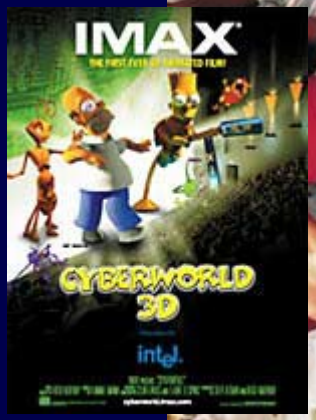
http://www.sarnoff.com/search/tech_papers/hybrid/index.asp

Motivation

Extremely High Visual Quality

Stereo Creation & Projection
4K-8K digital resolution per eye
World's Largest Film Format



IMAX 3D Content

CG Animations
Live Action
Mixed CG & Live Action

Limitations on IMAX 3D Content Creation

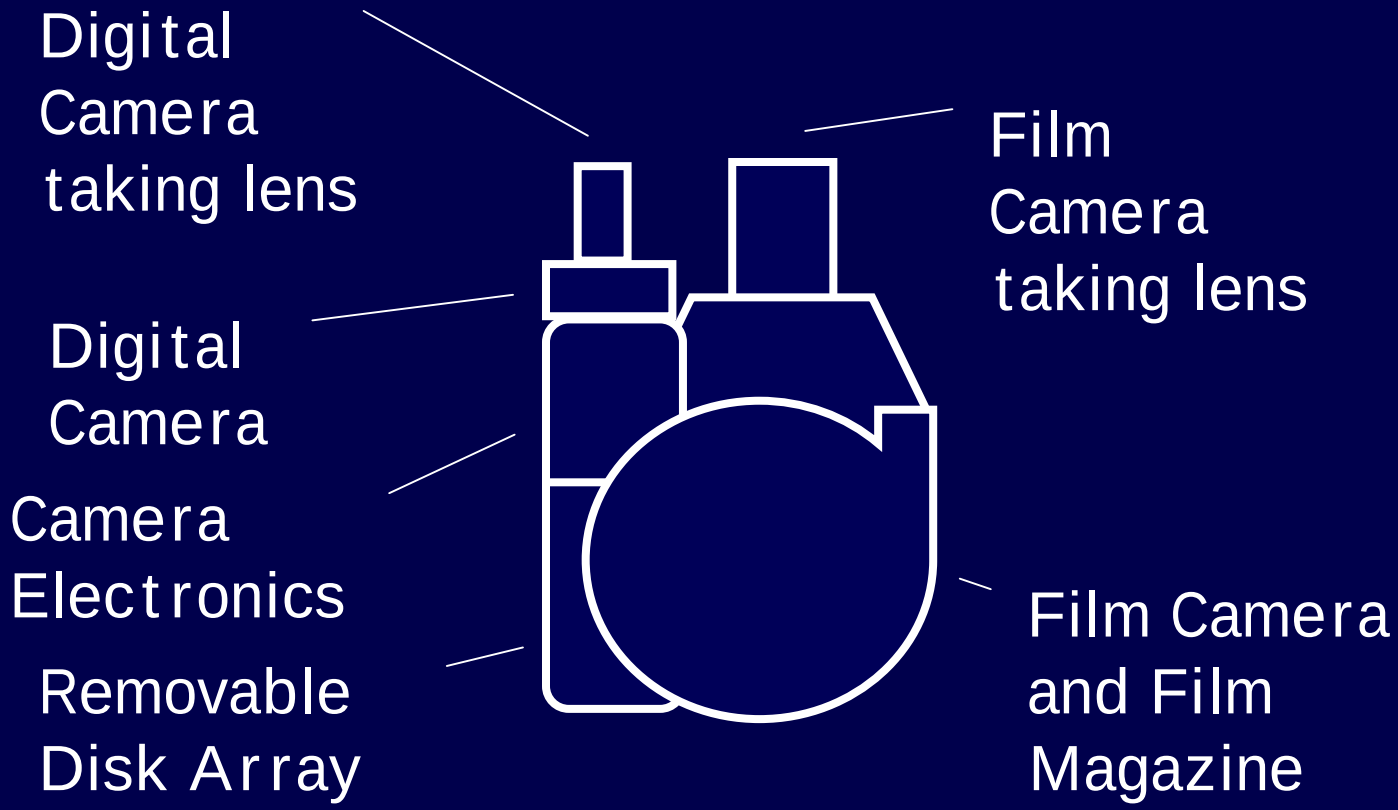
Live Action Content

- Camera is very large.
- Requires two strips of large format film.
- Size of camera and cost of film limits production.

CG Content

- 6-14 hours rendering time per frame!

Solution: Hybrid Stereo Camera



Goals

Expand the possibilities for 3D Cinematography:

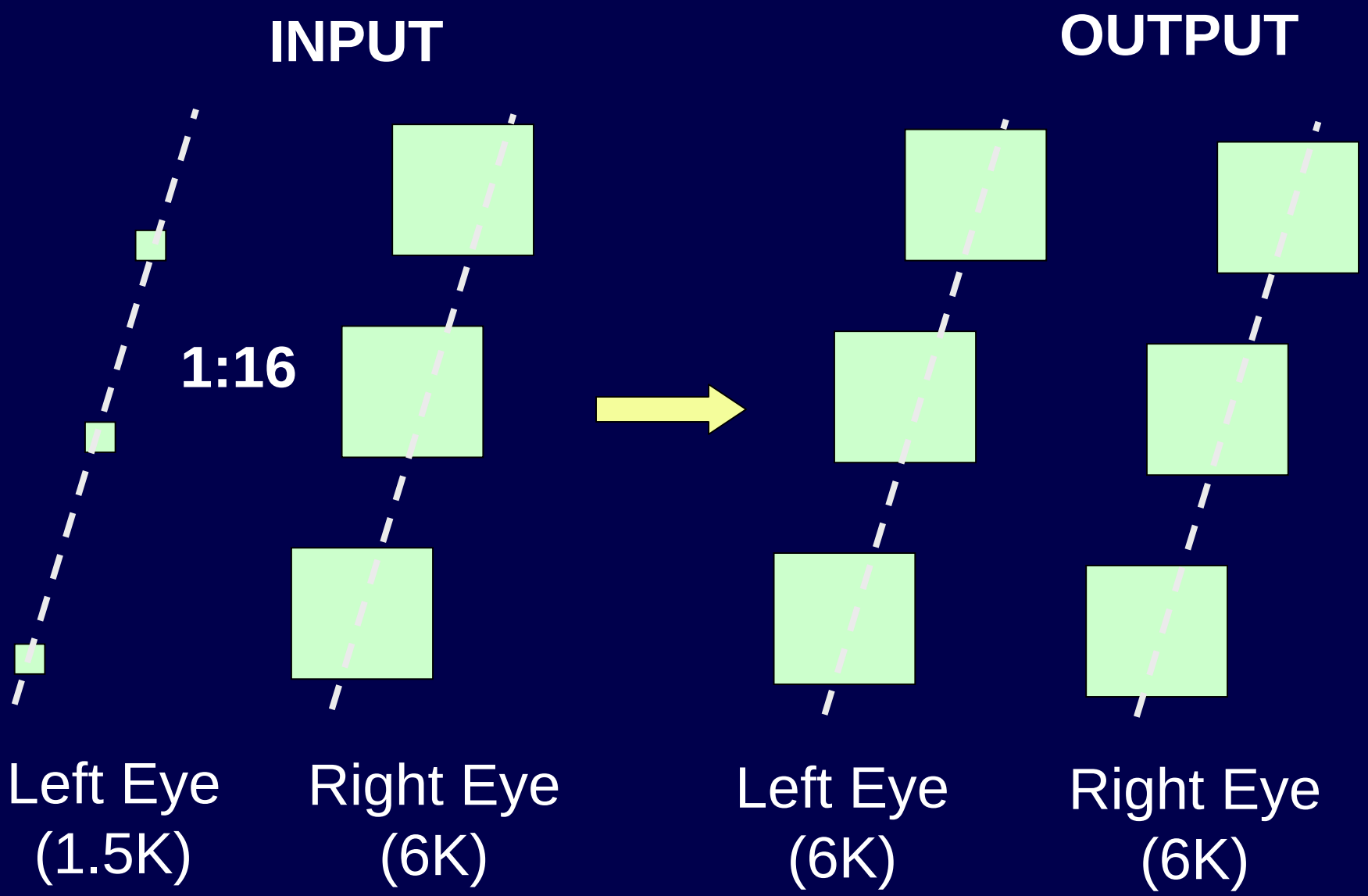
Can Computer Vision & IBR deliver High Quality ?

With reduced cost & time ?

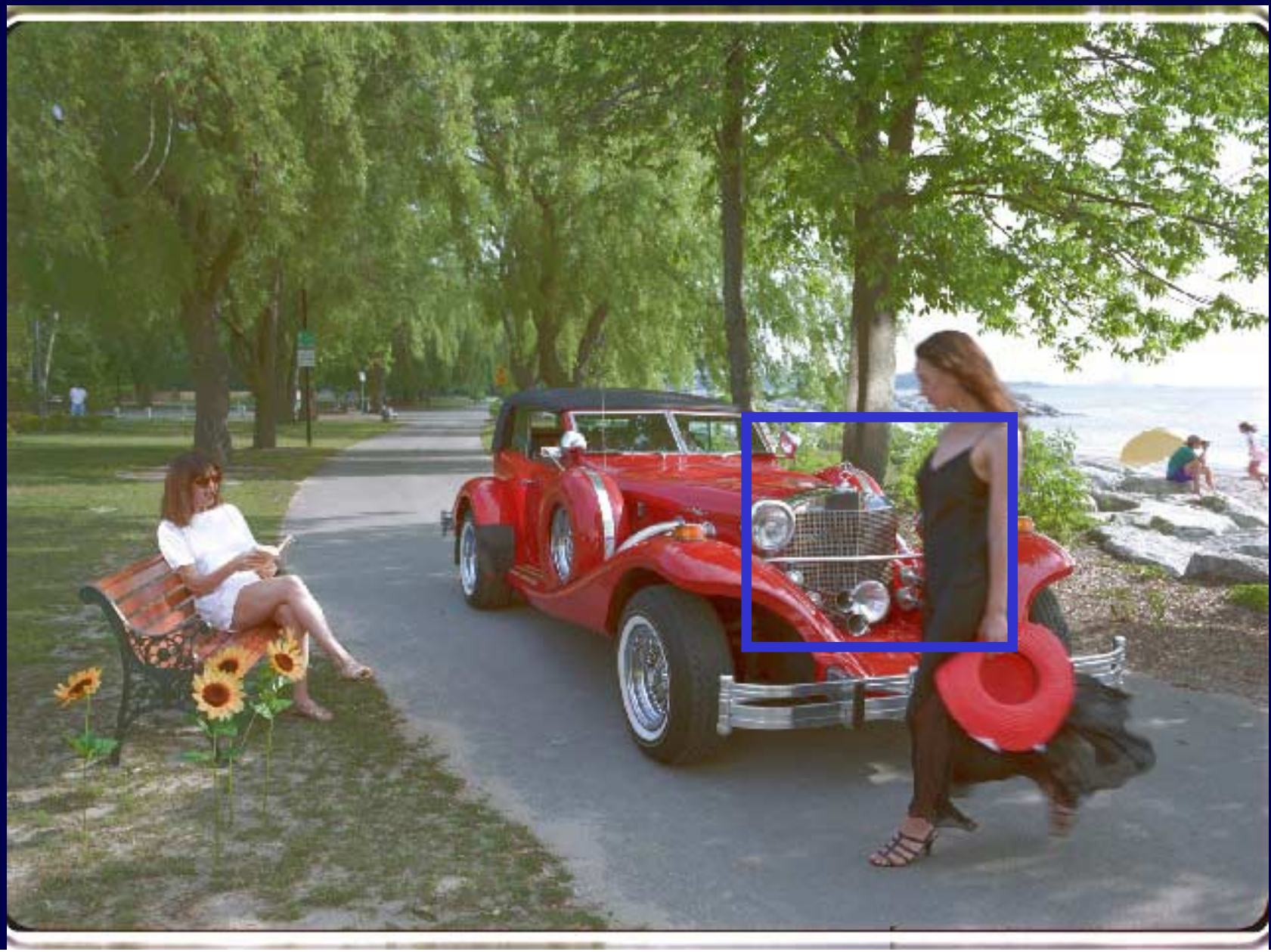
Explore an Analysis-Test-Synthesis Framework
for
Image-based Modeling & Rendering

Hybrid Stereo Camera

... pure upsampling is not an option ...



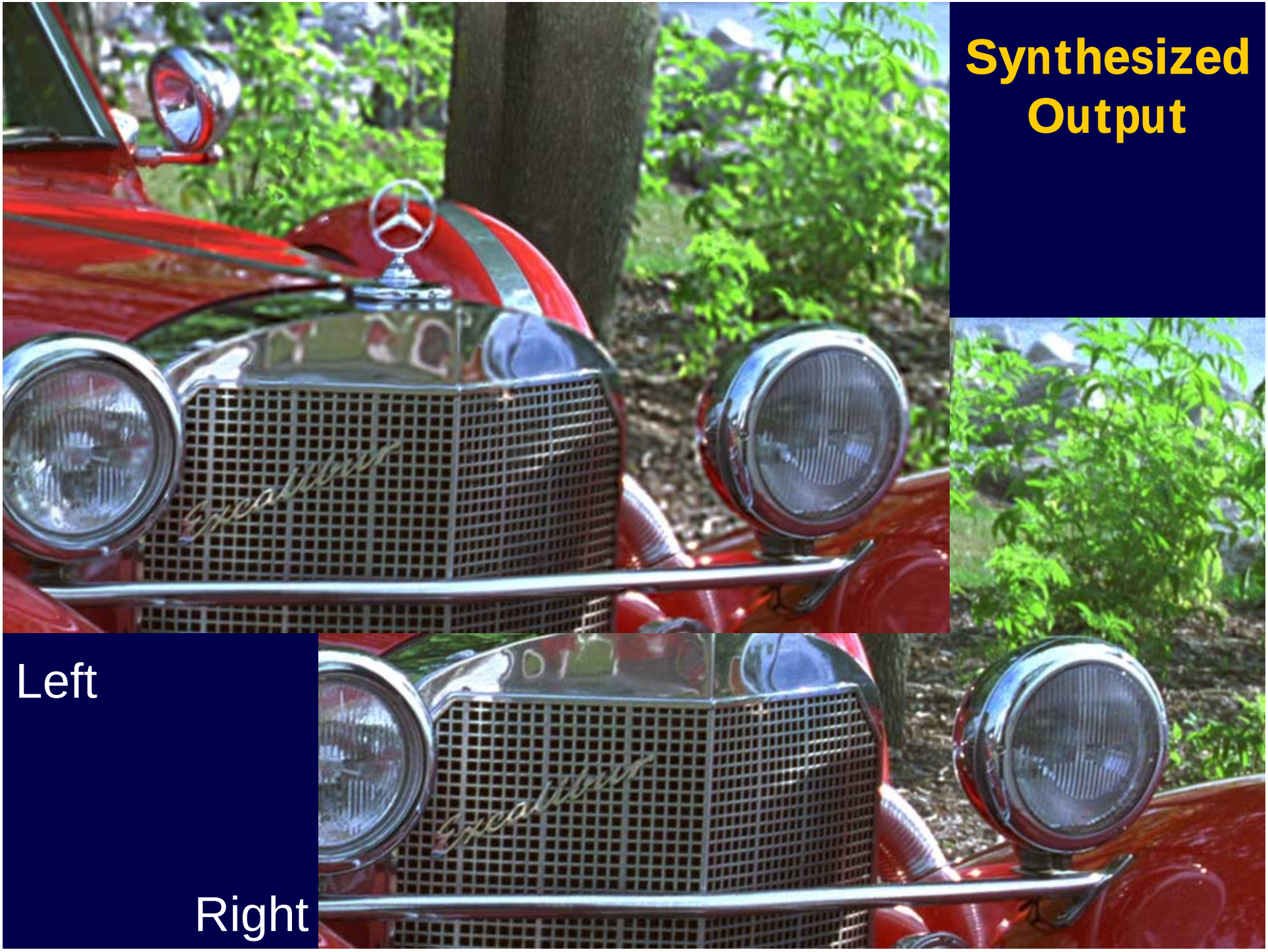
Live Action Sequence



Live Action : Hybrid Input

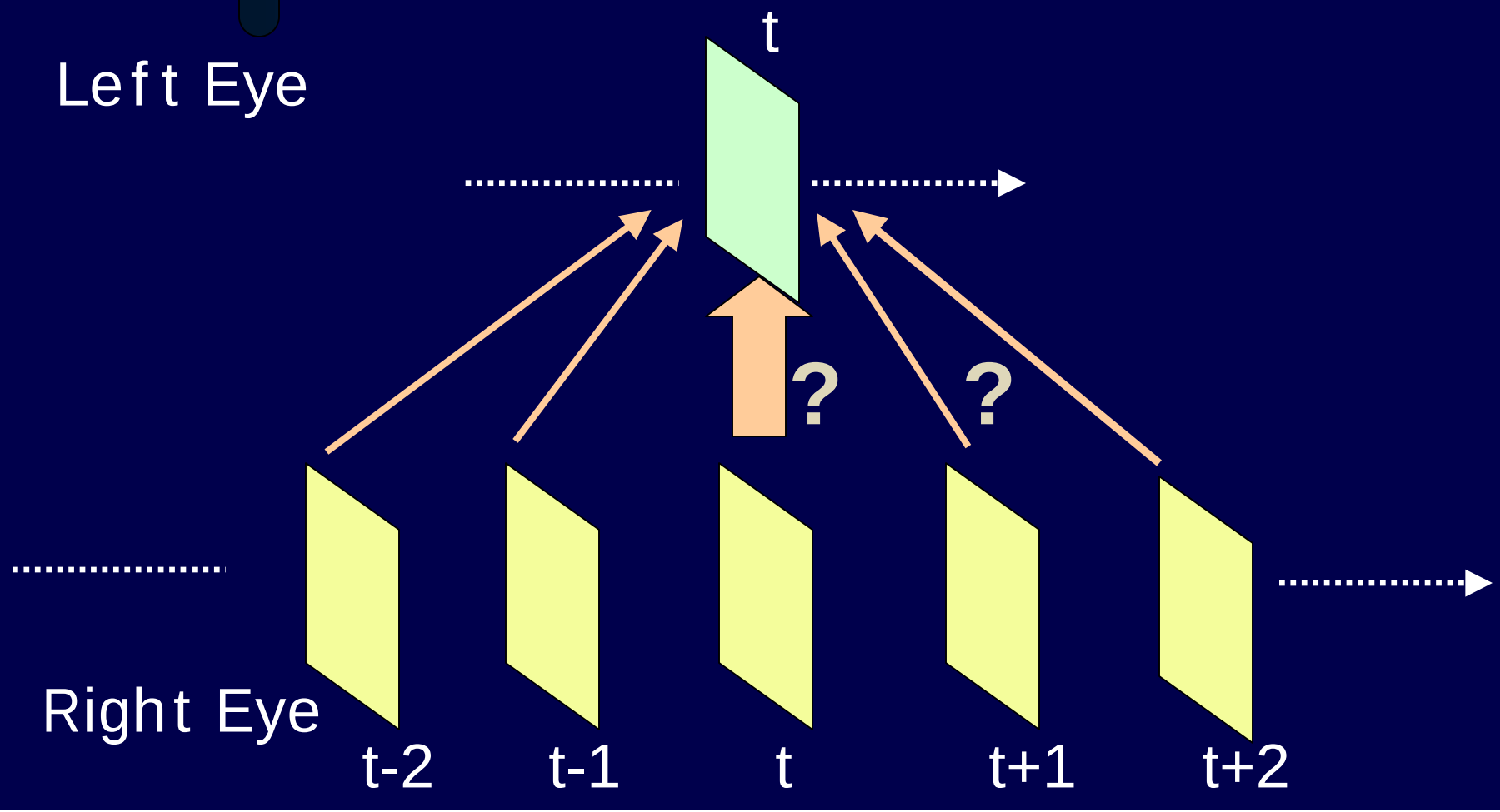
Left

Right


Synthesized Output
Left
Right

How can the Hybrid Camera be Realized ?

Render the High-Res content into the coordinate system of the Low-Res Frame !



Approach

Convergence of Computer Vision & IBR

- Compute stereo disparities at lo-res.
- Compute motion (Optical Flow) at lo-res.
- Compute quality map at lo-res.
- Synthesize hi-res frame.
- Fill-in and color correct mis-matched pixels.
- Temporal de-scintillation.

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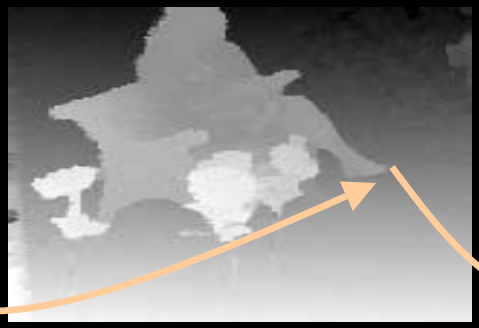
Establishing Stereo/Motion Correspondences

Analysis

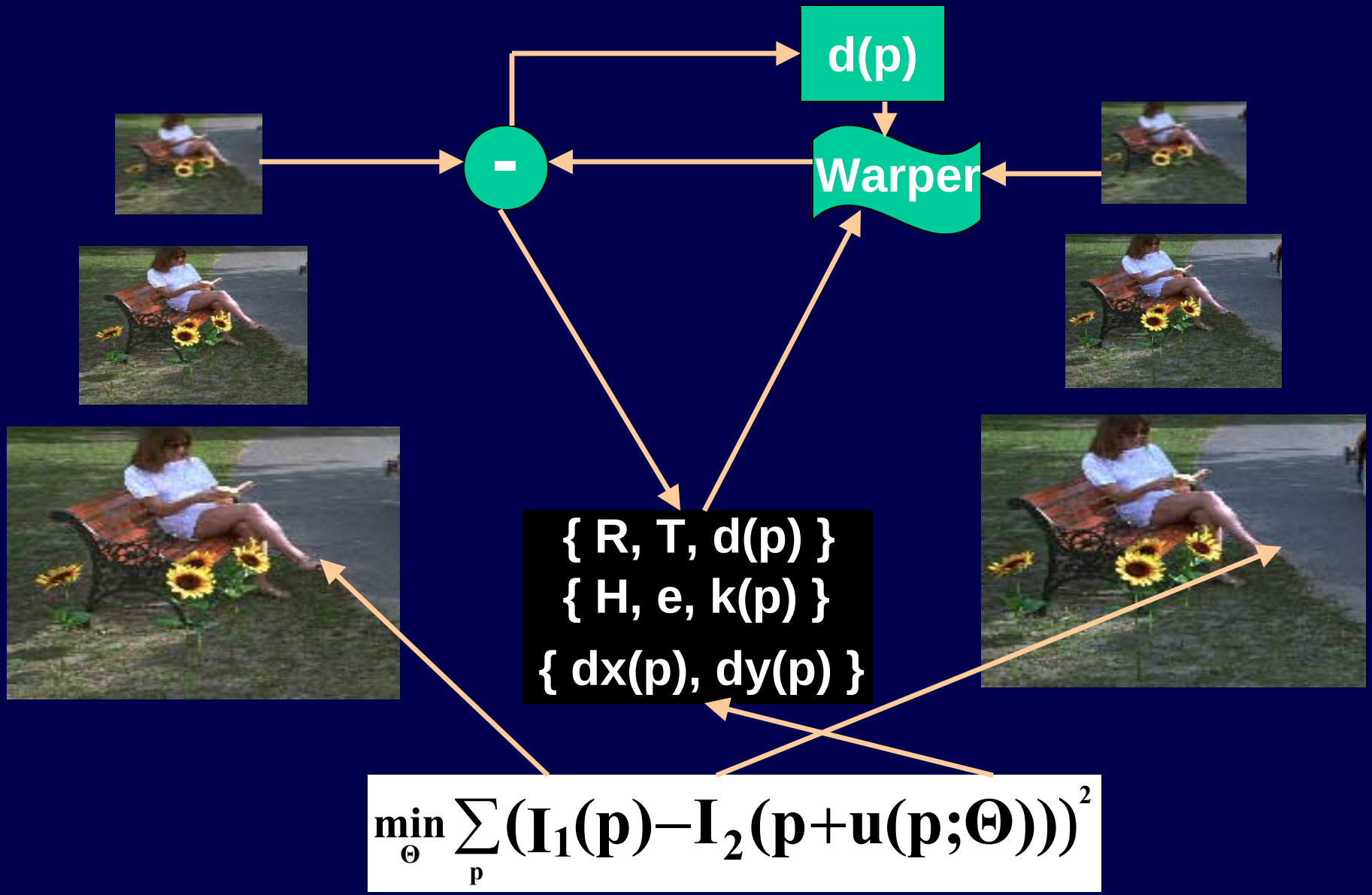
Left Eye
Time t

Right Eye
Time t, t'

Synthesis



Correspondences by Coarse-to-fine Model-based Image Alignment : A Primer



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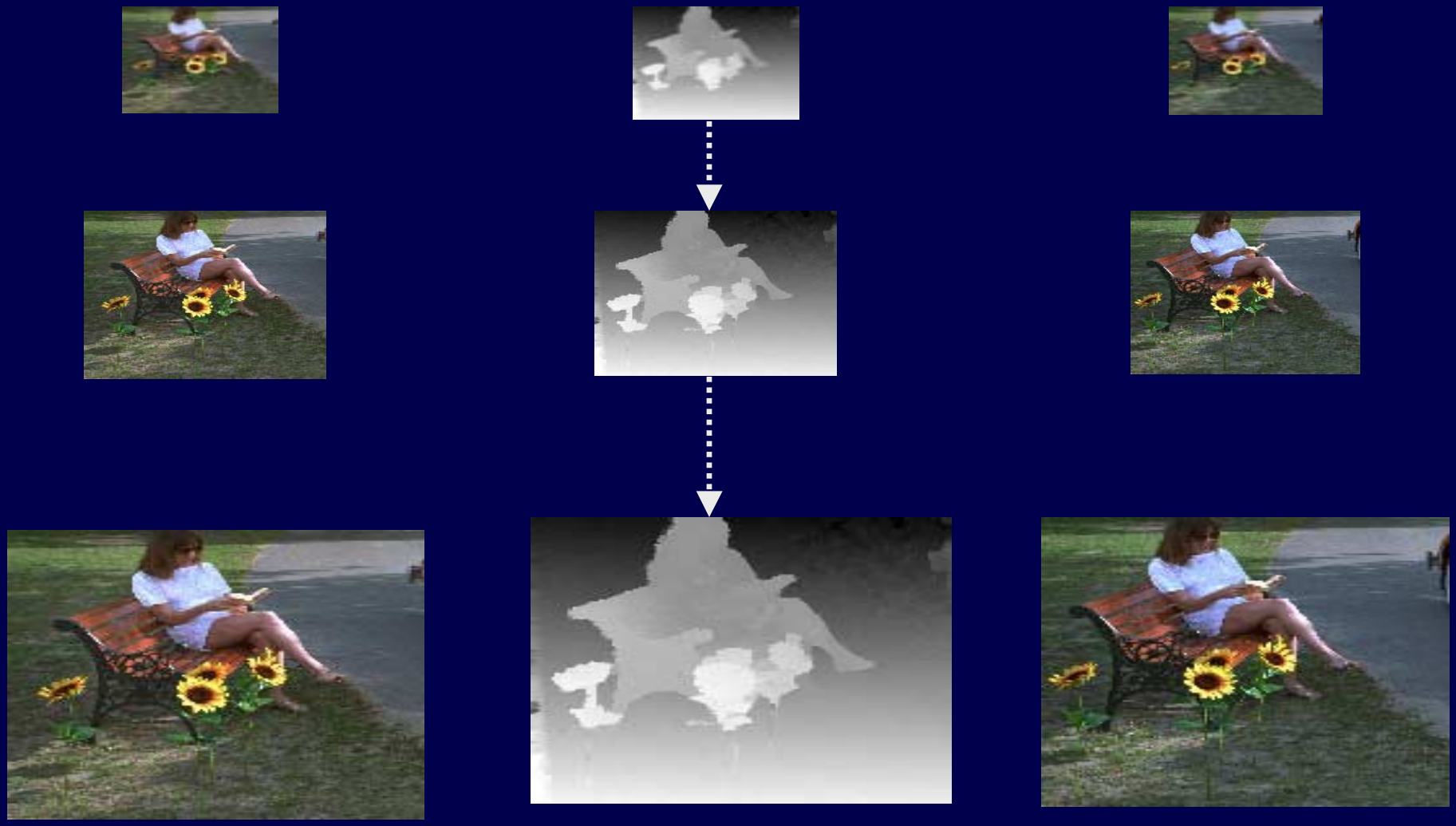
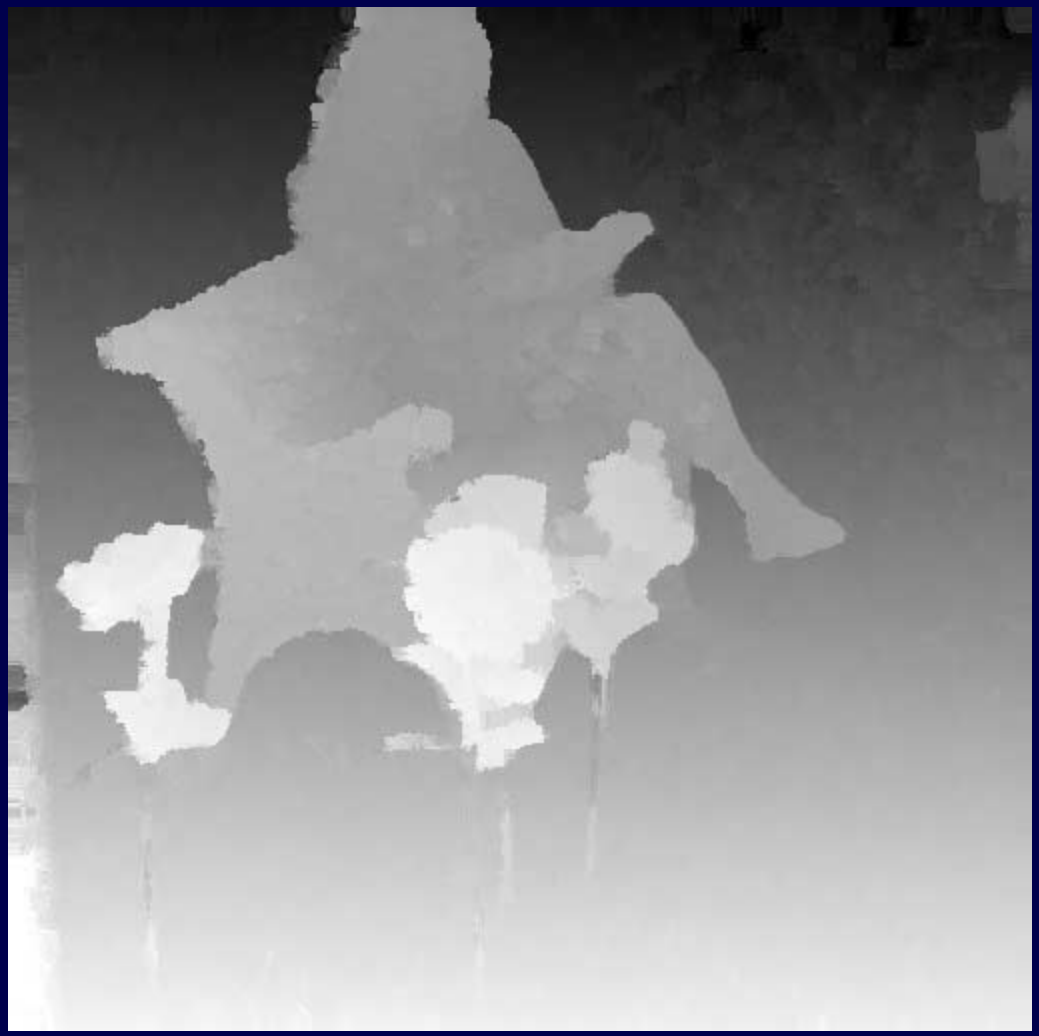


3D Stereo Correspondence

Original Left-Right Pair

3D Stereo Correspondence

Disparity/Correspondence Map



3D Stereo Correspondence

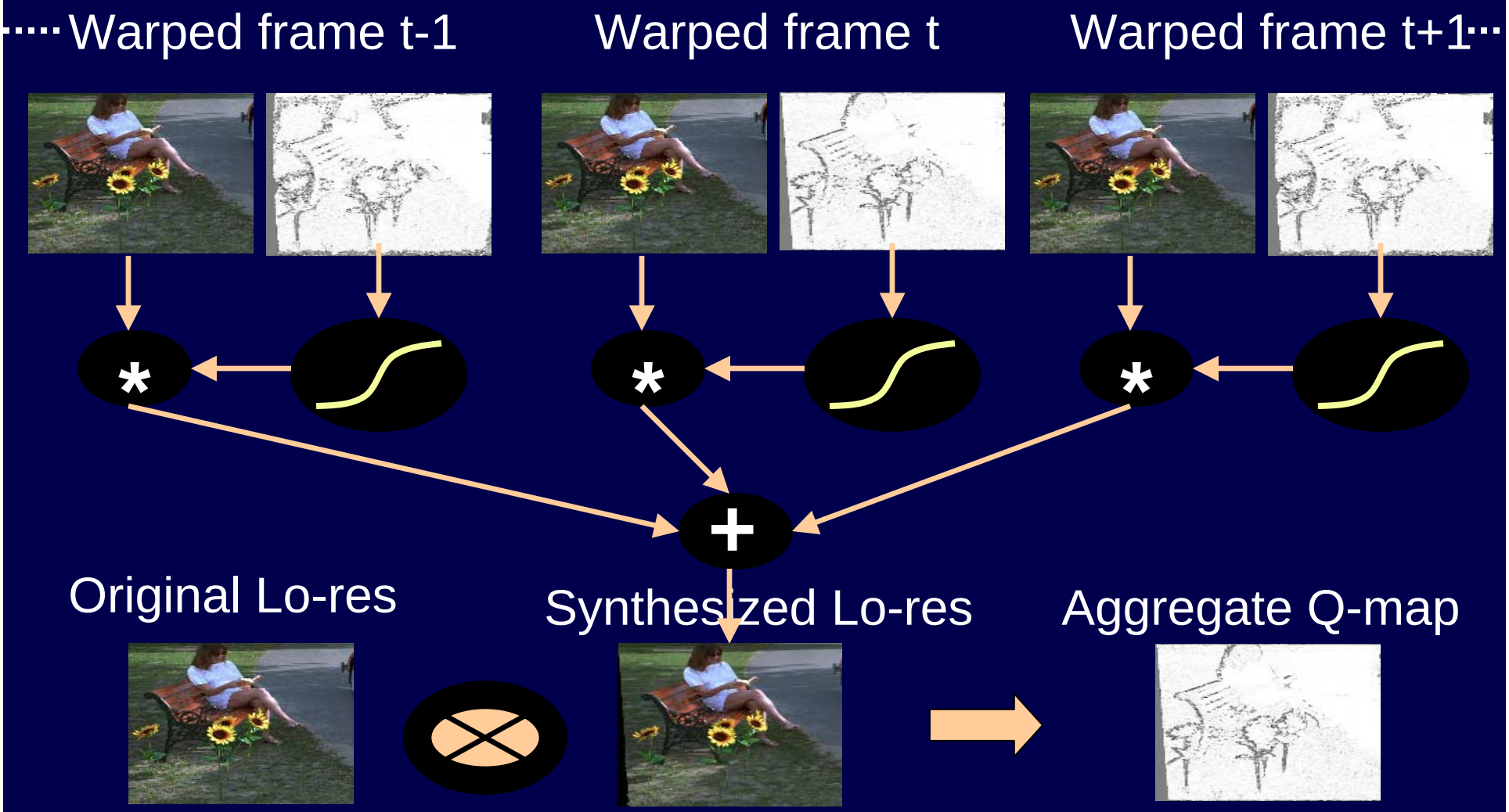
Original Left & Disparity-warped Right Frame

Quality of Alignment Map

Associate a [0,1] value at each pixel

Aggregate Quality Map at Lo-Res

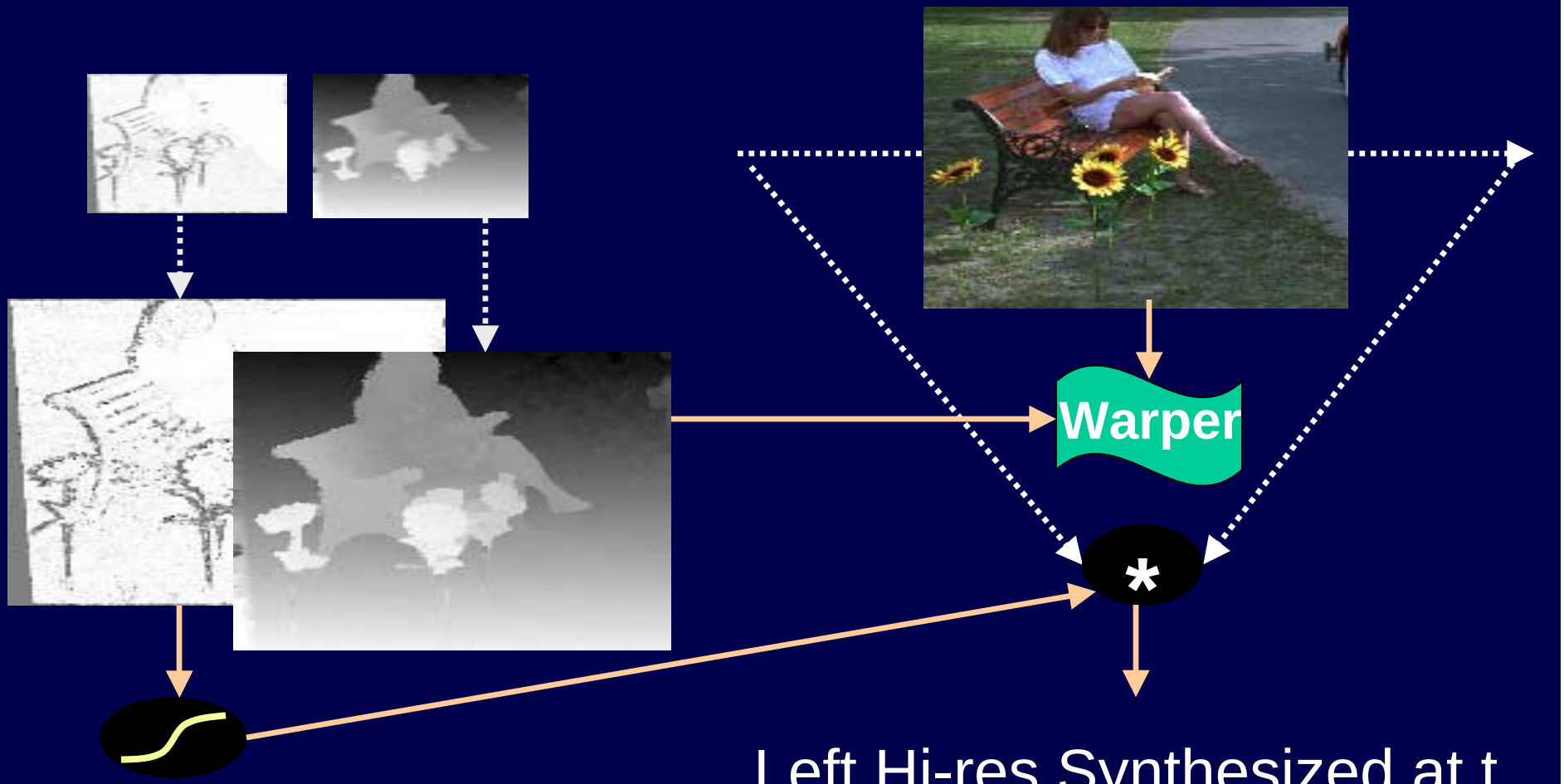
Using Stereo-Motion Synthesis



Synthesis at the High-Resolution

Left Lo-res Original at t

Right Hi-res Original at t



Left Hi-res Synthesized at t

Filling-in Mismatched Pixels at Hi-res

Hi-res Synthesized frame

Hi-res Q-map

Y

q > thresh

N

Up-resed frame

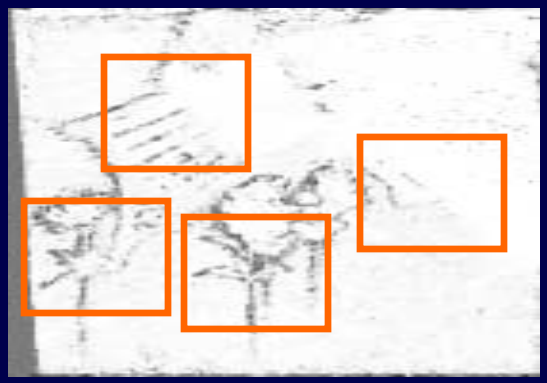
Filling-in Mismatched Pixels at Hi-Res

Sample Result

Color Correction

Synthesized
Hi-res frame

Hi-res Q-map



Use Matched Pixels to solve
for a Color Model:
Color(p') = A * Color(p) + b

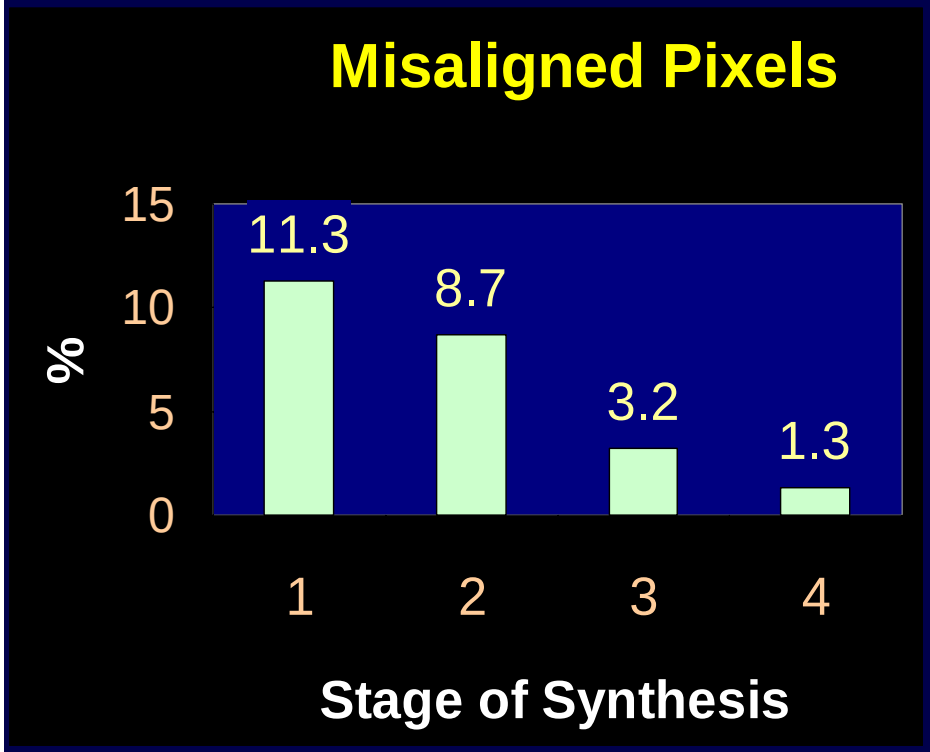
Apply Model to Mismatched
Pixels

Up-resed frame

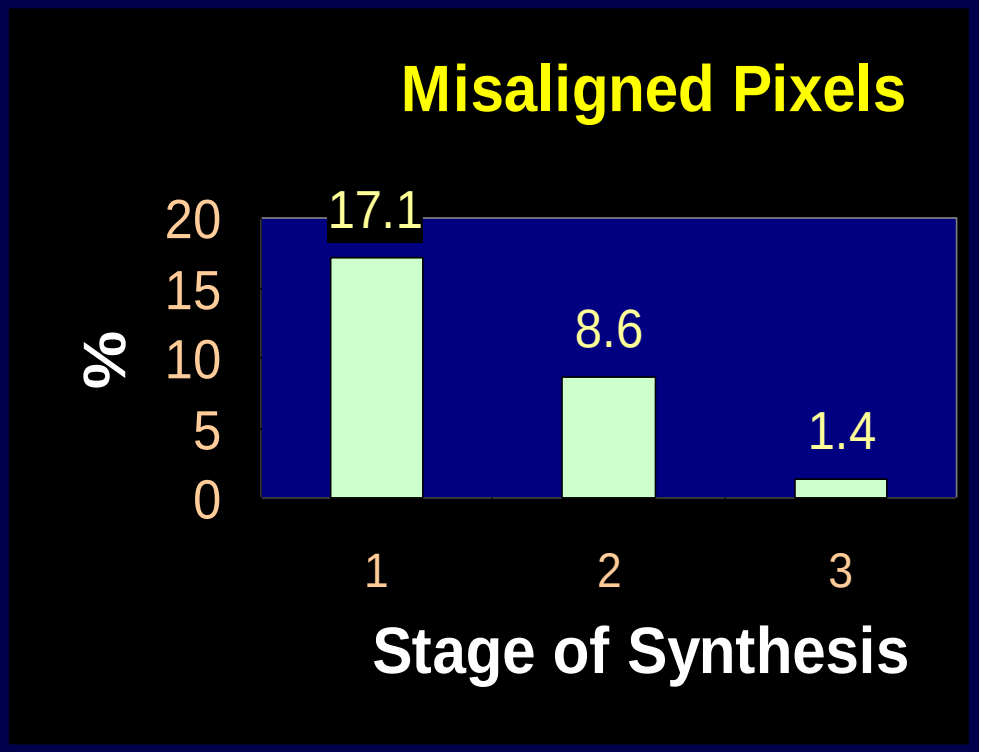
Color Correction

Sample Result

Quantitative Validation

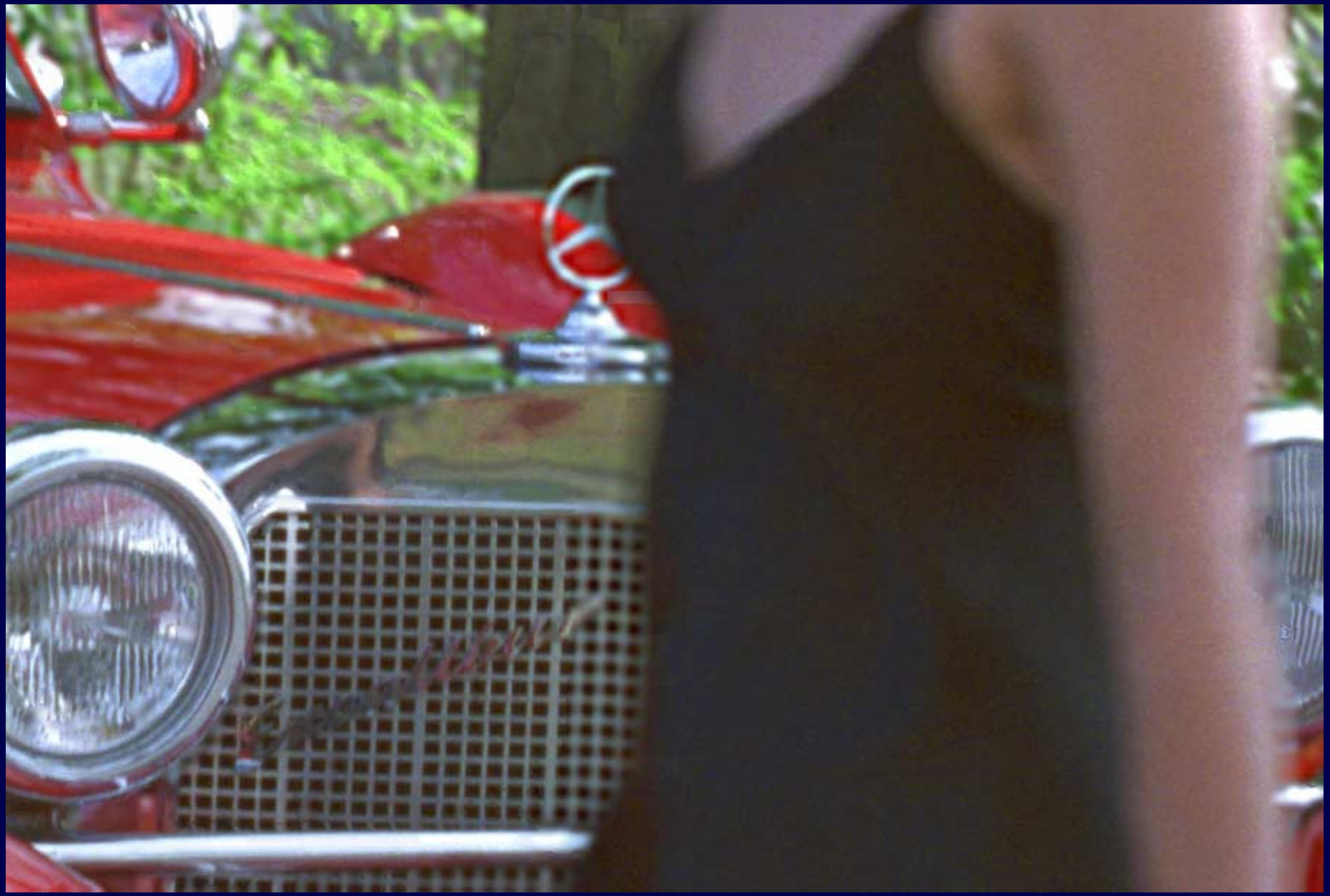


Live Action



CG Animation

Synthesis vs. Up-resing : Live Action



Synthesis vs. Up-resing : CG Animation

Computational Time

- Research Code : Currently about 45 mins. per 4K frame on an SGI 350 Mhz Octane.

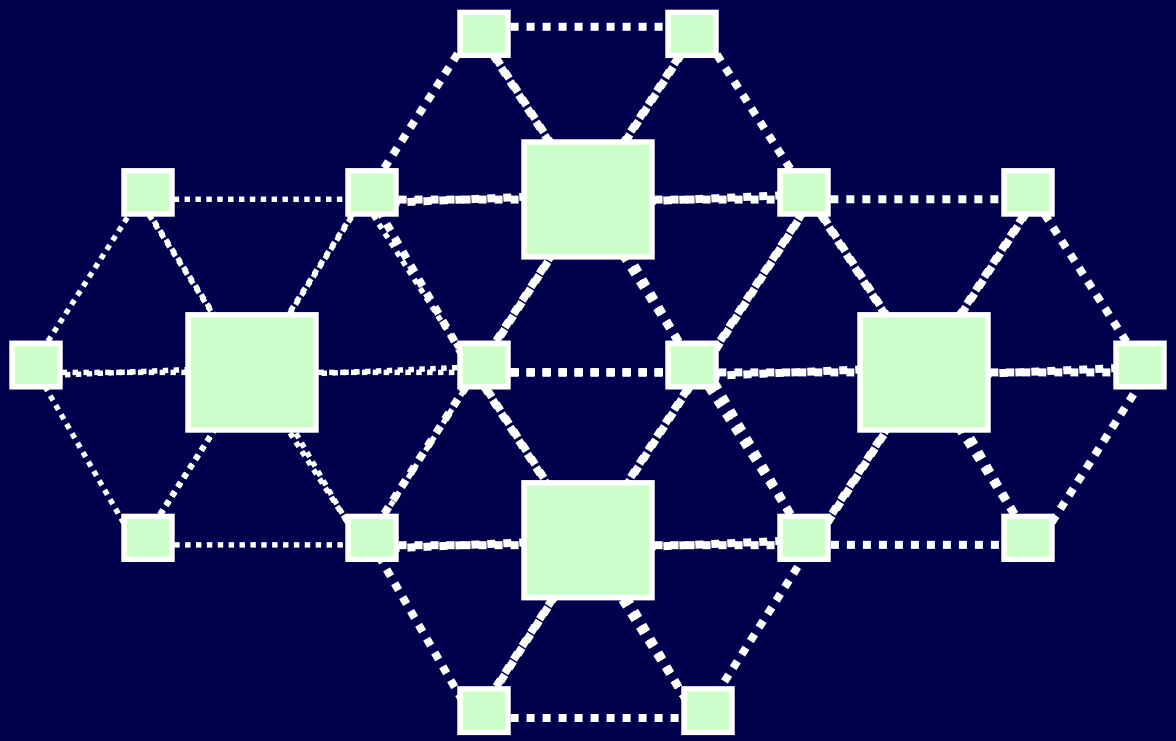
- Optimizations can easily reduce the time to about 4-5 mins.

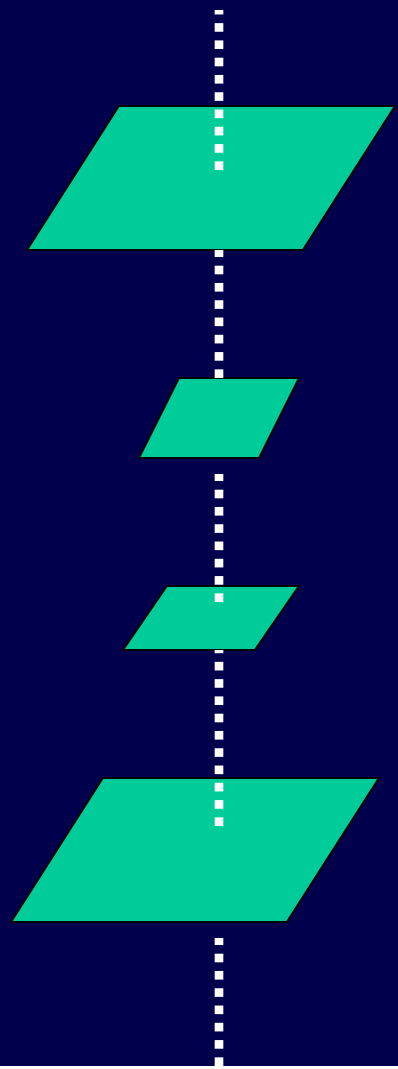
Potential cost/time reduction for a 45 min. feature

180 CPUs / 6 months ⇒ 30 CPUS / 2.5 months

Generalizations

Key Idea : IBMR can exploit the availability of lower resolution or other similar data for high quality rendering.





Summary

- Applied an Analysis-Test-Synthesis Framework to high quality stereo synthesis.
- Initial validation of quality of synthesis is very encouraging.
- Potential for new research and applications based on generalizations of the framework.

Acknowledgements

- Ed Lepieszo & Carol Harrison, IMAX
  - Help with demos and frame synthesis.
- Vince Paragano & Doug Corliss, Sarnoff
  - Software and systems support.
- Spans & Partner Inc., and IMAX
  - CG and Live Action Stereo Sequences.


The End

Related Work

- Perception of mismatched stereo pairs
  - Julesz'71, Perkins'92, Stelmach et al.'00
- Multi-resolution 3D/image sequence analysis
  - Bergen et al.'92, Hanna et al.'93
- Alignment quality measures
  - Irani et al.'94, Szeliski'99, Lubin'92

Temporal De-scintillation

Problem

- Synthesis is uncorrelated over time.
- Produces temporal scintillation.

Solution

- Smooth quality maps over time before using them for compositing.

Outstanding Issues

- Evaluation of JND based quality maps.
- Adaptive combination of stereo and motion frames.
- Issues related to real hybrid camera design.

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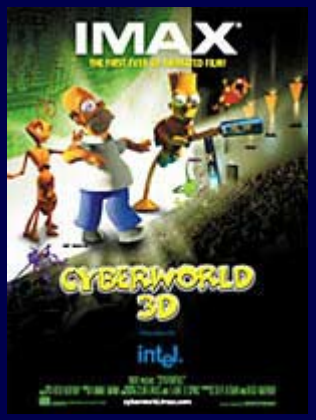

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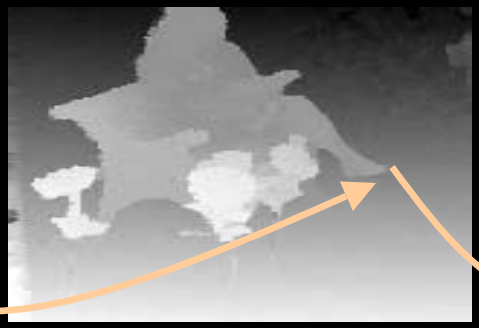

3D Movie Demo

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